

Appl. No. 09/730,813

Reply to Office Action of January 7, 2004

LISTING OF CLAIMS

This listing of claims replaces all prior versions and listings of claims in the patent application.

Claim 1 (previously presented): A surface treatment apparatus for making raw material gas plasma by generating plasma, in a casing provided with plasma generation means, a raw material gas inlet and a substrate support table, by the plasma generation means and giving plasma treatment to the surface of a substrate placed on said substrate support table, wherein:

said casing is defined into two chambers, a plasma generation chamber provided with said plasma generation means and a substrate treatment chamber provided with said substrate support table;

said substrate treatment chamber and said plasma generation chamber are connected through one or more plasma nozzles;

at least one of said plasma nozzles is made a hollow electrode discharge generation area; and

an opening width $W(1)$ of the smallest portion on the plasma nozzles is set in a range satisfying $10 \text{ mm} < W(1) \leq 100 \text{ mm}$.

Claim 2 (cancelled)

Claim 3 (withdrawn): A surface treatment apparatus for making raw material gas plasma by generating plasma, in a casing provided with plasma generation means, a raw material gas inlet and a substrate support table, by the plasma generation means and giving plasma treatment to the surface of a substrate placed on the substrate support table, wherein:

said casing is defined into two chambers, a plasma generation chamber provided with said plasma generation means and a substrate treatment chamber provided with said substrate support table;

said substrate treatment chamber and said plasma generation chamber are connected through one or more plasma nozzles;

at least one of said plasma nozzles is made a hollow discharge generation area; and

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a hollow plasma generation electrode comprising one or more hollow discharge generation areas is disposed in said plasma generation chamber.

Claim 4 (cancelled)

Claim 5 (previously presented): A surface treatment apparatus according to claim 1, wherein said plasma nozzle forms a substantially continuous and elongated slit shape that can be drawn with a single stroke of the brush.

Claim 6 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle is whorl shaped.

Claim 7 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle is meandering shaped.

Claim 8 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle is connected straight lines shaped.

Claim 9 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle is formed symmetrically in respect with its center.

Claim 10 (original): A surface treatment apparatus according to claim 5, wherein a slit width W of the plasma nozzle is set in a range satisfying either of $W \leq 5L(e)$ or $W \leq 20X$:

where $L(e)$ is an electron mean free path in respect to atom or molecular species (active species) of the smallest diameter among raw material gas species and electrically neutral atom or molecular species (active species) produced therefrom by decomposition, under the desired plasma generation conditions; and

X is a thickness of a sheath layer generated under the desired plasma generation conditions.

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Claim 11 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle varies its slit width from a center to an outer circumference thereof.

Claim 12 (original): A surface treatment apparatus according to claim 5, wherein said plasma nozzle varies its slit depth from a center to an outer circumference thereof.

Claim 13 (withdrawn): A surface treatment apparatus according to claim 2 or 3, wherein said hollow plasma generation electrode includes one or more recesses on a surface opposed to plasma generated by the plasma generation means and, at least one of the recesses is made the hollow discharge generation area.

Claim 14 (withdrawn): A surface treatment apparatus according to claim 2 or 3, wherein said hollow plasma generation electrode is a hollow body, said electrode includes one or more through holes communicating with a hollow inside on a portion opposed to plasma generated by the plasma generation means and, at least one of said through holes is made the hollow discharge generation area.

Claim 15 (withdrawn): A surface treatment apparatus according to claim 13 or 14, wherein an opening width $W(2)$ of the smallest portion of the recess or the through hole is set in a range satisfying either of $W(2) \leq 5L(e)$ or $W(2) \leq 20X$:

where $L(e)$ is an electron mean free path in respect to atom or molecular species (active species) of the smallest diameter among raw material gas species and electrically neutral atom or molecular species (active species) produced therefrom by decomposition, under the desired plasma generation conditions; and

X is a thickness of a sheath layer generated under the desired plasma generation conditions.

Claim 16 (withdrawn): A surface treatment apparatus according to claim 2, 3 or 14, wherein said hollow plasma generation electrode is a hollow body, said electrode includes one or more through holes communicating with a hollow inside on a portion opposed to plasma

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generated by the plasma generation means and, a hollow discharge generation area is made in at least a portion of the hollow inside.

Claim 17 (withdrawn): A surface treatment apparatus according to claim 16, wherein an opposed face distance H in the hollow inside along the formation direction of said through hole of the hollow plasma generation electrode is set in a range satisfying either of $H \leq 5L(e)$ or $H \leq 20X$:

where $L(e)$ is an electron mean free path in respect to atom or molecular species (active species) of the smallest diameter among raw material gas species and electrically neutral atom or molecular species (active species) produced therefrom by decomposition, under the desired plasma generation conditions; and

X is a thickness of a sheath layer generated under the desired plasma generation conditions.

Claim 18 (withdrawn): A surface treatment apparatus of one of claims 1 to 17, wherein a magnetic field is formed in the vicinity of said plasma nozzle and/or in the vicinity of said recess, through hole, and/or in the hollow inside.

Claim 19 (previously presented): A surface treatment apparatus of one of claims 1 and 5-12, wherein said apparatus comprises potential applying means for applying a desired potential to the substrate.